UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
National Vehicle and Fuel Emissions Laboratory
2565 Plymouth Road, Ann Arbor, Michigan 48105

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MEMORANDUM

SUBJECT: Development of On-Highway Inventory Adjustment Factors Used in the Tier 2 Final Rule Air Quality Analysis

FROM: John Koupal
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TO: Docket A-97-10

In support of the Tier 2 final rulemaking, national emission inventories of NOx, VOC, PM and SOx were generated by OAQPS and their contractor, E.H. Pechan & Associates, for 1996, 2007 and 2030. These emission inventories, generated with and without the effects of Tier 2 vehicle and sulfur standards, formed the basis of the air quality and cost-benefit analyses presented in the rule. The on-highway mobile source portion of these inventories were developed by first running the current official versions of on-highway modeling software, MOBILE5b and PART5. For NOx and VOC, the estimated effects of select changes planned for the next generation of MOBILE (MOBILE6) and the effects of Tier 2/Sulfur control were accounted for by applying adjustment factors to the MOBILE5b output. For PM and SOx, the effects of Tier 2/Sulfur control were accounted for by applying adjustment factors to the PART5 output. All adjustment factors were developed by OMS and applied by OAQPS and Pechan. The purpose of this memo is to explain how these adjustment factors were derived and how they were applied. Adjustment factors were generated for four general vehicle categories (light-duty gasoline, light-duty diesel, heavy-duty gasoline, heavy-duty diesel), and are discussed separately here.

Light-Duty Gasoline Vehicle and Trucks

NOx (without air conditioning) and Exhaust VOC

NOx and exhaust VOC adjustments factors were generated based on a comparison of MOBILE5b and the Tier 2 Model, first developed for use in the Tier 2 NPRM.[1] The Tier 2 Model incorporates several elements which were proposed for incorporation into MOBILE6,

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[1] Koupal, J., "Development of Light-Duty Emission Inventory Estimates in the Notice of Proposed Rulemaking for Tier 2 and Sulfur Standards", EPA420-R-99-005, March 1999 (Koupal, March 1999). Hereafter referred to as the "Light-Duty Inventory Report".

including draft estimates of revised deterioration rates and the effects of off-cycle operation and fuel sulfur. The version of the Tier 2 Model used for the NPRM was developed in a spreadsheet format; a subsequent version of the model, known as Modified MOBILE5b Version 2 (MM5b2) incorporated minor updates, and converted the format to the MOBILE model input file structure.[2] For this analysis, MM5b2 input files were developed using NOx emission rates which did not reflect air conditioning usage; the effects of air conditioning usage on NOx emissions were accounted for separately, as described in a later section.

A comparison of gram per mile emission factors output by MM5b2 and MOBILE5b yielded multiplicative adjustment factors by vehicle class and calendar year, which were applied to the county-by-county MOBILE5b results generated by OAQPS and Pechan.[3] MM5b2 was run over eight scenarios covering four combination of fuel (RFG and Conventional) and I/M (with or without) program, over both the baseline and control scenarios, in three calendar years: 1996, 2007 and 2030. The RFG case assumed 150 ppm fuel, while the Conventional gasoline (CG) case assumed 330 ppm. The I/M program assumed to be in place was an enhanced IM240 with phase-in cutpoints for pre-Tier 1 vehicles, and an OBD-based I/M program for Tier 1 and later vehicles.[4]

The results from the MM5b2 runs served as the numerator in the equation to derive the multiplicative "MOBILE5-to-MOBILE6"[5] adjustment factors; the denominator in this equation were the results of MOBILE5b runs, executed in such a manner as to isolate the effect of the estimated MOBILE6 changes. MOBILE5b was run over six combinations of fuel program (RFG and Conventional) and I/M program ("Regular" I/M, "Max" I/M[6], and No I/M). The "Regular" I/M case was developed to mimic the I/M program assumed in MM5b2; phase-in IM240 cutpoints for Tier 0 vehicles, and (to estimate the effects of OBD-based I/M, which MOBILE5 does not include) final cutpoints for Tier 1 and later vehicles. The detailed specifications used for the MOBILE5b I/M runs are included in the following table:

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[2] Kremer, J., "Description of Modifications Used In Input Files for Modified MOBILE5b Version 2", Memo to Docket A-97-10, October 1999

[3] The MM5b2 model, MM5b2 input/output files and MOBILE5b input/output files used for this analysis are contained on CD in Docket A-97-10.

[4] Koupal, J. and Glover, E., "Determination of NOx and HC Basic Emission Rates, OBD and I/M Effects for Tier 1 and later LDVs and LDTs", EPA420-P-99-009, March 1999

[5] Effects of "MOBILE6"as referred to in this document are those estimated based on draft proposals which are subject to change.

[6] Max I/M is also referred to as "Appropriate I/M" in some documentation. For details on this feature in MOBILE5b, See "Memorandum on Emission Reduction Credits for California Low Emission Vehicles (LEVs)", Memorandum from Phil Lorang to EPA Regional Air Directors, Appendix 2B of the MOBILE5 User's Guide.

Start Year	1986
Stringency	20%
Model Years (Phase-In Cutpoints)	1968 through 1995
Model Years (Final Cutpoints)	1996 through 2030
Waiver Rate (Phase-In/Final)	10/3%
Compliance Rate	85%
Program Type	Test Only
Inspection Frequency	Annual
Vehicles Subject To Inspection	LDGV, LDGT1 (< 6000 lbs), LDGT2 (> 6000 lbs)
Test Type	IM240
HC/NOx Cutpoints (Phase-In)	1.2 / 3.0 grams/mile
HC/NOx Cutpoints (Final)	0.8 / 2.0 grams/mile

The Max I/M case was added in order to provide adjustment factors which could be applied specifically to those counties invoking the Max I/M feature for LEVs in MOBILE5b; this feature has a significant effect on LEV emissions, and warranted separate treatment. Thus, in developing adjustment factors for a particular I/M case, the appropriate "With I/M" MM5b2 run was used in the numerator, but the MOBILE5b run used in the denominator depended on the program being modeled - Max I/M for those counties invoking this feature, and Regular I/M for all other counties with I/M programs. The MOBILE5b runs with Max I/M used the I/M program detailed above for pre-LEVs.

In order to isolate the effects of model changes due to emission rates, off-cycle, sulfur effects and fleet characteristics, MOBILE5b was run under the same conditions as MM5b2. The MOBILE5b runs were done at 24.6 mph, the average speed of the LA92 cycle used to develop off-cycle effects in MM5b2, and hence the inherent average speed of the MM5b2 model.[7] MOBILE5b was also run without temperature effects (i.e. an ambient temperature of 75° F), since (aside from air conditioning, as discussed later) no temperature corrections were made to the emission rates in MM5b2. Although MM5b2 eliminated most of the emission tampering effects imbedded in MOBILE5b, MOBILE5b was run with these effects so that the adjustment factors would reflect the elimination of these effects between MOBILE5 and MOBILE6.

For the three calendar years, multiplicative adjustment factors were developed for each vehicle class over a total of twelve scenarios, representing each combination of three I/M cases (none, regular, max), two fuel cases (RFG and Conventional), and two control cases (baseline and with Tier 2/Sulfur). These adjustments were generated by dividing MM5b2 emission factors by the MOBILE5b emission factors for the appropriate pairing of model output. The twelve

[7]Use of a single average speed by MM5b2 is a rough approximation of the speed approach proposed for MOBILE6, which will incorporate a range of speeds over multiple roadway types. As a result, the MOBILE5-to-MOBILE6 adjustment factors are likely less accurate at the high and low ends of the speed range.

scenarios were derived by pairing the MM5b2 and MOBILE5b runs as shown in the tables below:

1996 NOx

Scenario	MM5b2 Case	MOBILE5b Case
No IM/Conventional/Baseline	No IM/Conventional/Baseline	No IM/Conventional
No IM/Conventional/Control	No IM/Conventional/Control	
Reg IM/Conventional/Baseline	IM/Conventional/Baseline	Reg IM/Conventional
Reg IM/Conventional/Control	IM/Conventional/Control	
Max IM/Conventional/Baseline	IM/Conventional/Baseline	Max IM/Conventional
Max IM/Conventional/Control	IM/Conventional/Control	
No IM/RFG/Baseline	No IM/Conventional*/Baseline	No IM/RFG
No IM/RFG/Control	No IM/Conventional*/Control	
Reg IM/RFG/Baseline	IM/Conventional*/Baseline	Reg IM/RFG
Reg IM/RFG/Control	IM/Conventional*/Control	
Max IM/RFG/Baseline	IM/Conventional*/Baseline	Max IM/RFG
Max IM/RFG/Control	IM/Conventional*/Control	

* For this analysis, no NOx benefit was estimated for Phase I RFG; this is represented by treating CG as the Phase I RFG case. This only applied to the calendar year 1996 runs.

1996 Exhaust VOC

Scenario	MM5b2 Case	MOBILE5b Case
No IM/Conventional/Baseline	No IM/Conventional/Baseline	No IM/Conventional
No IM/Conventional/Control	No IM/Conventional/Control	
Reg IM/Conventional/Baseline	IM/Conventional/Baseline	Reg IM/Conventional
Reg IM/Conventional/Control	IM/Conventional/Control	
Max IM/Conventional/Baseline	IM/Conventional/Baseline	Max IM/Conventional
Max IM/Conventional/Control	IM/Conventional/Control	
No IM/RFG/Baseline	No IM/RFG&CG*/Baseline	No IM/RFG
No IM/RFG/Control	No IM/RFG&CG*/Control	
Reg IM/RFG/Baseline	IM/RFG&CG*/Baseline	Reg IM/RFG
Reg IM/RFG/Control	IM/RFG&CG*/Control	
Max IM/RFG/Baseline	IM/RFG&CG*/Baseline	Max IM/RFG
Max IM/RFG/Control	IM/RFG&CG*/Control	

* For this analysis, the VOC benefit of Phase I RFG is estimated to be ½ that of Phase II RFG; this is represented by treating the average of Phase II RFG and CG as the Phase I RFG case. This only applied to calendar year 1996.

2007 and 2030 NOx and Exhaust VOC

Scenario	MM5b2 Case	MOBILE5b Case
No IM/Conventional/Baseline	No IM/Conventional/Baseline	No IM/Conventional
No IM/Conventional/Control	No IM/Conventional/Control	
Reg IM/Conventional/Baseline	IM/Conventional/Baseline	Reg IM/Conventional
Reg IM/Conventional/Control	IM/Conventional/Control	
Max IM/Conventional/Baseline	IM/Conventional/Baseline	Max IM/Conventional
Max IM/Conventional/Control	IM/Conventional/Control	
No IM/RFG/Baseline	No IM/RFG/Baseline	No IM/RFG
No IM/RFG/Control	No IM/RFG/Control	
Reg IM/RFG/Baseline	IM/RFG/Baseline	Reg IM/RFG
Reg IM/RFG/Control	IM/RFG/Control	
Max IM/RFG/Baseline	IM/RFG/Baseline	Max IM/RFG
Max IM/RFG/Control	IM/RFG/Control	

The resulting adjustment factors are shown in Appendix A. Every county in the nationwide inventory (excluding California[8]) was assigned one of these twelve scenarios by Pechan. The adjustment factors generated from this methodology were then applied to all MOBILE5b output under all conditions. Overall, the use of a limited number adjustment factors to estimate MOBILE6 emissions under all conditions is necessarily simplistic. The inherent assumption behind this approach is that the relative difference between MM5b2 and MOBILE5b under a discrete set of conditions can be broadly applied to all scenarios. For example, differences between MOBILE5b and MM5bs for a single (pre-LEV) I/M program were applied to all I/M programs nationwide; differences between draft MOBILE6 mileage accumulation and age distributions and MOBILE5b defaults were applied to all areas, even if local inputs for these parameters were used; and adjustment factors developed at a single speed and temperature were applied across all speeds and temperatures. While limited, this approach was necessary in the absence of a complete MOBILE6 model.

Air Conditioning (NOx Only)

The effects of air conditioning usage on NOx emissions were accounted for through an additive adjustment (in grams per mile) which was added to the emission factor after the MOBILE5-to- MOBILE6 adjustment factor was applied. The spreadsheet version of the Tier 2 Model was run with and without the effect of air conditioning to generate a “full usage” emission adjustment by calendar year and vehicle class, reflecting emissions which would be generated

[8]California inventories were developed by Pechan using CALI5; no adjustments were made to the CALI5 results.

under full air conditioner load.[9] This adjustment was then scaled back to reflect the actual ambient conditions being modeled, based on an equation developed for MOBILE6 which estimates air conditioner load as a function of heat index (for this analysis, ambient temperature was substituted for heat index):[10]

$$(1)\ Activity\ Factor = -3.63 + 0.072465 * (Temp) - 0.000276 * (Temp)^2$$

Where:

Activity Factor = multiplicative factor applied to full-usage A/C adjustment (Max=1, Min=0)
Temp = ambient temperature being modeled (degrees F)

The full-usage air conditioning adjustments are shown in Appendix B for 1996, 2007 and 2030 by scenario and vehicle class.

Non-Exhaust VOC

Non-exhaust VOC multiplicative adjustments were developed to reflect the benefits of Tier 2 control only, based on the "Evaporative MOBILE5b" model developed for the Tier 2 NPRM run with and without Tier 2 control.[11] In the NPRM analysis, eight scenarios were developed, covering the four combinations of fuel and I/M across two geographic regions (North and South);[12] for the final rule analysis, adjustment factors were developed for the eight scenarios by dividing the control case results by the baseline case results, across vehicle class. These adjustment factors were then averaged across geographic region, resulting in four cases: RFG/IM, RFG/No IM, CG/IM, and CG/No IM. The resulting adjustments are shown in Appendix C. These adjustments were applied to the MOBILE5b runs conducted by Pechan and OAQPS to reflect the benefit of Tier 2 control; although no other MOBILE5-to-MOBILE6 corrections were applied, the benefits of OBD were estimated in the MOBILE5b runs by invoking an I/M pressure/purge program for 1996 and later LDVs and LDTs, regardless of whether the vehicle

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[9]See the Light-Duty Inventory Report for a description of how air conditioning was included in the emission rates used for the Tier 2 Model. The Tier 2 Model assumed an implicit air conditioning activity factor of 68 percent, with 5 percent of vehicles assumed to either not have A/C or have nonfunctioning A/C systems. For this analysis, the "full usage" emission adjustments were based on emission rates with and activity factor of 100 percent (the 5 percent factor was maintained).

[10] Koupal, J., "Air Conditioning Activity Effects in MOBILE6," MOBILE6 Draft Report M6.ACE.001, January 1998

[11] This model modified MOBILE5b's evaporative component by estimating the effects of Tier 2 control. This feature exists in MM5b2 as well, but the version of the model published with the NPRM was used to generate the adjustments shown in Appendix C. See "A Modified Version of MOBILE5 for Evaluation of Proposed Tier 2 Evaporative Emission Standards," Memo from David Brzezinski to Docket A-97-10.

[12]See Light-Duty Inventory Report, Section 7

was in an I/M area.[13]

PM

Multiplicative adjustments were developed for PM to reflect the benefits of the Tier 2 program only. These adjustments were developed by dividing Tier 2 Model results without Tier 2/Sulfur by Tier 2 Model results with Tier 2/Sulfur control, by calendar year and vehicle class. The Tier 2 Model incorporates mileage accumulation and age distributions planned for PART6, but with the exception of revised gasoline sulfur effects the emission rates are largely unchanged from PART5. Because of this, the focus of the adjustment factors was to estimate the effects of Tier 2 control on a PART5-based inventory, rather than developing PART5-to-PART6 adjustments. Since I/M is assumed not to affect PM emissions, the adjustments are identical across the I/M cases. These adjustments are shown in Appendix D.

SOx

Multiplicative adjustments were developed for SOx to reflect the benefits of the Tier 2 program only. These adjustments were based directly on dividing the post-control sulfur level (30 ppm) by the pre-control sulfur levels, as estimated by PART5 (138 for RFG, 340 for CG). This methodology was also used to generate adjustment factors for heavy-duty gasoline vehicles and motorcycles. The resulting adjustments for all classes are shown in Appendix D.

Light-Duty Diesel

NOx and VOC

Adjustment factors for light-duty diesel vehicles and trucks were calculated identically to gasoline light-duty adjustments. The MM5b2 and MOBILE5b runs generated for the development of gasoline adjustment factors were also used for light-duty diesels. For baseline scenarios, diesel emission rates used in the generation of adjustment factors were not changed from MOBILE5; however, differences in fleet characteristics (age distribution and mileage accumulation) result in differences between MOBILE6 and MOBILE5 that are constant by model year. For the control case, diesel BERs for 2004 and later vehicles were set equal to gasoline BERs (LDDV were set equal to LDGV, LDDT equal to LDGT2 since most diesel trucks are expected to be in the heavier weight class), and thus differences across I/M and fuel program are reflected within a given calendar year. These adjustments are shown in Appendix A.

PM

[13] Specifications of the pressure/purge program used to estimate OBD evaporative benefits for 1996 and later LDVs and LDTs: test only, biennial program, 96% compliance rate

Multiplicative adjustments were developed for PM to reflect the benefits of the Tier 2 program only. These adjustments were developed by dividing Tier 2 Model results without Tier 2/Sulfur by Tier 2 Model results with Tier 2/Sulfur control, by calendar year and vehicle class. Since I/M and gasoline fuel program do not affect diesel PM emissions, one adjustment applies in each calendar year. These adjustments are shown in Appendix D.

Heavy-Duty Gasoline

NOx (without air conditioning) and Exhaust VOC

Multiplicative adjustment factors for heavy-duty gasoline vehicles (Appendix A) were generated by comparing MM5b2 and MOBILE5b, using an identical methodology to that used for light-duty vehicles. As with light-duty vehicles, the effect of air conditioning was removed from the 2004 and later MM5b2 emission rates. The "with air conditioning" NOx emission rates for 2004 and later were reduced by 15 percent for the I/M case, and 14 percent for the non-I/M case, based on estimates of lifetime emissions for LEV LDT4s with and without air conditioning.

Air Conditioning

The effects of air conditioning usage on NOx emissions from heavy-duty gasoline vehicles were estimated using an additive emission factor adjustment (in grams per mile), identical to the approach used for light-duty gasoline vehicles. The Tier 2 Model was run with and without the effect of air conditioning to generate a "full usage" emission adjustment by calendar year, reflecting emissions which would be generated under full air conditioner load. This adjustment was then scaled back to reflect the actual ambient conditions being modeled, based on Equation (1). The "full-usage" air conditioning adjustments are shown in Appendix B.

PM

Multiplicative adjustments were developed for PM to reflect the benefits of the Tier 2 program only. These adjustments were developed for the conventional fuel case based on the NPRM inventory in Atlanta; PM inventory results without Tier 2/Sulfur were divided by results with Tier 2/Sulfur control, in 2007 and 2030. Adjustments for the RFG case were derived from the CG case, based on the difference in the RFG and CG adjustment for LDT3/4s. The resulting adjustments are shown in Appendix D.

SOx

Multiplicative adjustments were developed for SOx to reflect the benefits of the Tier 2 program only. These adjustments were based directly on dividing the post-control sulfur level (30 ppm) by the pre-control sulfur levels, as estimated by PART5 (138 for RFG, 340 for CG).

Heavy-Duty Diesel

NOx

MOBILE5b emissions factors do not reflect the effects of excess NOx emissions produced by heavy-duty diesel vehicles (HDDV) as the result of built-in defeat devices. These effects will be incorporated in MOBILE6. MOBILE6 will also incorporate updated heavy-duty emission factors, emission conversion factors, VMT distribution by vehicle class, and VMT distribution by model year. Because a final version of MOBILE6 is not yet available, we have developed two spreadsheet models that allow us to estimate emission factors with and without defeat devices for a range of speeds and roadway types. One of these spreadsheet models estimates HDDV emission factors with and without defeat devices assuming all MOBILE6 changes in underlying data. A second spreadsheet model estimates HDDV emission factors with and without defeat devices using MOBILE5b assumptions about HDDV emissions factors, conversion factors, and VMT distribution.

Using these models, we calculated the ratios of MOBILE6 with defeat device emission factors over MOBILE5 without defeat device emission factors by speed and roadway type. These ratios were than multiplied by the MOBILE5 emission factors developed by OAQPS and the Pechan-Avanti Group in order to adjust them to reflect both the defeat device effect and the effects of other MOBILE6 assumptions.

The spreadsheet models, the methods used to develop them, and the ratios developed from them are more thoroughly described in ADevelopment and Use of Heavy-Duty NOx Defeat Device Emission Effects for MOBILE5 and MOBILE6", by Ed Glover, Report Number M6.HDE.003, September 1999.

VOC

Multiplicative adjustment factors were developed for VOC emissions from heavy-duty diesel vehicles to reflect several draft updates of MOBILE5b, including the effects of new standards, new emission rates, and fleet characteristics. The adjustments were developed by dividing MM5b2 HDDV emission factor results in 2007 and 2030 by MOBILE5b results in the same years. The “MOBILE5-to-MOBILE6" adjustment factors for each year were 0.41 for 2007 and 0.32 for 2030.

APPENDIX A

“MOBILE5-To-MOBILE6" Adjustment Factors for NOx And Exhaust VOC

(Regular and Max I/M)

Table A-1
"MOBILE5-to-MOBILE6" Multiplicative Adjustments
NOx - Regular I/M (without Air Conditioning)

Year	Case	Scenario	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT
1996	BASELINE	IM CG	0.849	0.823	0.855	1.169	1.104	1.152
		IM RFG	0.861	0.832	0.861	1.171	1.104	1.152
		NO IM CG	0.796	0.761	0.812	1.169	1.104	1.152
		NO IM RFG	0.807	0.769	0.817	1.171	1.104	1.152
	CONTROL	IM CG	n/a	n/a	n/a	n/a	n/a	n/a
		IM RFG	n/a	n/a	n/a	n/a	n/a	n/a
		NO IM CG	n/a	n/a	n/a	n/a	n/a	n/a
		NO IM RFG	n/a	n/a	n/a	n/a	n/a	n/a
2007	BASELINE	IM CG	0.720	0.805	0.786	0.897	1.095	1.132
		IM RFG	0.659	0.768	0.777	0.848	1.095	1.132
		NO IM CG	0.651	0.716	0.700	0.902	1.095	1.132
		NO IM RFG	0.602	0.686	0.695	0.866	1.095	1.132
	CONTROL	IM CG	0.485	0.575	0.598	0.784	0.740	0.694
		IM RFG	0.511	0.599	0.620	0.795	0.739	0.688
		NO IM CG	0.454	0.524	0.542	0.793	0.741	0.719
		NO IM RFG	0.476	0.547	0.564	0.804	0.740	0.714
2030	BASELINE	IM CG	0.624	0.690	0.796	0.313	1.084	1.140
		IM RFG	0.504	0.627	0.792	0.284	1.084	1.140
		NO IM CG	0.600	0.635	0.663	0.328	1.084	1.140
		NO IM RFG	0.490	0.583	0.652	0.335	1.084	1.140
	CONTROL	IM CG	0.118	0.134	0.127	0.230	0.118	0.161
		IM RFG	0.124	0.142	0.133	0.231	0.116	0.159
		NO IM CG	0.167	0.190	0.167	0.256	0.219	0.303
		NO IM RFG	0.173	0.199	0.174	0.260	0.210	0.298

Table A-2
“MOBILE5-to-MOBILE6" Multiplicative Adjustments
NOx - Max I/M (without Air Conditioning)

Year	Case	Scenario	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT
1996	BASELINE	IM CG	0.849	0.823	0.855	1.169	1.104	1.152
		IM RFG	0.861	0.832	0.861	1.171	1.104	1.152
		NO IM CG	0.796	0.761	0.812	1.169	1.104	1.152
		NO IM RFG	0.807	0.769	0.817	1.171	1.104	1.152
	CONTROL	IM CG	n/a	n/a	n/a	n/a	n/a	n/a
		IM RFG	n/a	n/a	n/a	n/a	n/a	n/a
		NO IM CG	n/a	n/a	n/a	n/a	n/a	n/a
		NO IM RFG	n/a	n/a	n/a	n/a	n/a	n/a
2007	BASELINE	IM CG	0.883	0.983	0.786	0.897	1.095	1.132
		IM RFG	0.809	0.937	0.777	0.848	1.095	1.132
		NO IM CG	0.651	0.716	0.700	0.902	1.095	1.132
		NO IM RFG	0.602	0.686	0.695	0.866	1.095	1.132
	CONTROL	IM CG	0.594	0.703	0.598	0.784	0.740	0.694
		IM RFG	0.626	0.732	0.620	0.795	0.739	0.688
		NO IM CG	0.454	0.524	0.542	0.793	0.741	0.719
		NO IM RFG	0.476	0.547	0.564	0.804	0.740	0.714
2030	BASELINE	IM CG	1.997	1.657	0.796	0.313	1.084	1.140
		IM RFG	1.614	1.508	0.792	0.284	1.084	1.140
		NO IM CG	0.600	0.635	0.663	0.328	1.084	1.140
		NO IM RFG	0.490	0.583	0.652	0.335	1.084	1.140
	CONTROL	IM CG	0.377	0.321	0.127	0.230	0.118	0.161
		IM RFG	0.397	0.341	0.133	0.231	0.116	0.159
		NO IM CG	0.167	0.190	0.167	0.256	0.219	0.303
		NO IM RFG	0.173	0.199	0.174	0.260	0.210	0.298

Table A-3
"MOBILE5-to-MOBILE6" Multiplicative Adjustments
Exhaust VOC - Regular I/M

Year	Case	Scenario	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT
1996	BASELINE	IM CG	0.724	0.773	0.874	0.899	1.231	1.385
		IM RFG	0.789	0.827	0.927	0.913	1.231	1.385
		NO IM CG	0.681	0.777	0.840	0.899	1.231	1.385
		NO IM RFG	0.744	0.811	0.882	0.913	1.231	1.385
	CONTROL	IM CG	n/a	n/a	n/a	n/a	n/a	n/a
		IM RFG	n/a	n/a	n/a	n/a	n/a	n/a
		NO IM CG	n/a	n/a	n/a	n/a	n/a	n/a
		NO IM RFG	n/a	n/a	n/a	n/a	n/a	n/a
2007	BASELINE	IM CG	0.398	0.417	0.502	0.431	1.224	1.345
		IM RFG	0.395	0.413	0.502	0.399	1.224	1.345
		NO IM CG	0.333	0.370	0.461	0.444	1.224	1.345
		NO IM RFG	0.344	0.373	0.461	0.413	1.224	1.345
	CONTROL	IM CG	0.343	0.357	0.416	0.383	0.917	0.874
		IM RFG	0.366	0.377	0.446	0.377	0.907	0.853
		NO IM CG	0.298	0.326	0.391	0.396	0.939	0.907
		NO IM RFG	0.325	0.351	0.420	0.391	0.905	0.881
2030	BASELINE	IM CG	0.255	0.263	0.445	0.096	1.216	1.357
		IM RFG	0.251	0.267	0.433	0.090	1.216	1.357
		NO IM CG	0.221	0.242	0.313	0.137	1.216	1.357
		NO IM RFG	0.223	0.253	0.319	0.134	1.216	1.357
	CONTROL	IM CG	0.204	0.208	0.155	0.080	0.285	0.266
		IM RFG	0.220	0.211	0.162	0.078	0.253	0.222
		NO IM CG	0.195	0.208	0.154	0.122	0.355	0.494
		NO IM RFG	0.209	0.219	0.167	0.122	0.422	0.424

Table A-4
"MOBILE5-to-MOBILE6" Multiplicative Adjustments
Exhaust VOC -Max I/M

Year	Case	Scenario	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT
1996	BASELINE	IM CG	0.724	0.773	0.874	0.899	1.231	1.385
		IM RFG	0.789	0.827	0.927	0.913	1.231	1.385
		NO IM CG	0.681	0.777	0.840	0.899	1.231	1.385
		NO IM RFG	0.744	0.811	0.882	0.913	1.231	1.385
	CONTROL	IM CG	n/a	n/a	n/a	n/a	n/a	n/a
		IM RFG	n/a	n/a	n/a	n/a	n/a	n/a
		NO IM CG	n/a	n/a	n/a	n/a	n/a	n/a
		NO IM RFG	n/a	n/a	n/a	n/a	n/a	n/a
2007	BASELINE	IM CG	0.492	0.540	0.502	0.431	1.224	1.345
		IM RFG	0.494	0.539	0.502	0.399	1.224	1.345
		NO IM CG	0.333	0.370	0.461	0.444	1.224	1.345
		NO IM RFG	0.344	0.373	0.461	0.413	1.224	1.345
	CONTROL	IM CG	0.424	0.463	0.416	0.383	0.917	0.874
		IM RFG	0.457	0.493	0.446	0.377	0.907	0.853
		NO IM CG	0.298	0.326	0.391	0.396	0.939	0.907
		NO IM RFG	0.325	0.351	0.420	0.391	0.905	0.881
2030	BASELINE	IM CG	1.525	1.539	0.445	0.096	1.216	1.357
		IM RFG	1.506	1.564	0.433	0.090	1.216	1.357
		NO IM CG	0.221	0.242	0.313	0.137	1.216	1.357
		NO IM RFG	0.223	0.253	0.319	0.134	1.216	1.357
	CONTROL	IM CG	1.222	1.217	0.155	0.080	0.285	0.266
		IM RFG	1.321	1.234	0.162	0.078	0.253	0.222
		NO IM CG	0.195	0.208	0.154	0.122	0.355	0.494
		NO IM RFG	0.209	0.219	0.167	0.122	0.422	0.424

APPENDIX B

NOx "Full Usage" Air Conditioning Adjustments

Table B-1
NOx “Full Usage” Air Conditioning Emission Factor Adjustments (grams per mile)

Year	Case	Scenario	LDGV	LDGT1	LDGT2	HDGV
1996	BASELINE	IM CG	0.282	0.298	0.334	0.000
		IM RFG	0.282	0.298	0.334	0.000
		NO IM CG	0.301	0.315	0.353	0.000
		NO IM RFG	0.301	0.315	0.353	0.000
	CONTROL	IM CG	n/a	n/a	n/a	n/a
		IM RFG	n/a	n/a	n/a	n/a
		NO IM CG	n/a	n/a	n/a	n/a
		NO IM RFG	n/a	n/a	n/a	n/a
2007	BASELINE	IM CG	0.194	0.161	0.237	0.080
		IM RFG	0.166	0.145	0.223	0.060
		NO IM CG	0.206	0.176	0.258	0.070
		NO IM RFG	0.178	0.159	0.245	0.070
	CONTROL	IM CG	0.141	0.131	0.194	0.050
		IM RFG	0.138	0.129	0.191	0.050
		NO IM CG	0.153	0.145	0.214	0.060
		NO IM RFG	0.150	0.142	0.211	0.050
2030	BASELINE	IM CG	0.083	0.044	0.146	0.197
		IM RFG	0.062	0.036	0.127	0.176
		NO IM CG	0.107	0.070	0.162	0.195
		NO IM RFG	0.081	0.059	0.156	0.174
	CONTROL	IM CG	0.038	0.027	0.033	0.145
		IM RFG	0.037	0.026	0.032	0.145
		NO IM CG	0.052	0.047	0.059	0.145
		NO IM RFG	0.051	0.046	0.058	0.144

APPENDIX C
Adjustment Factors for Evaporative (Non-Exhaust) VOC

Table C-1

Evaporative VOC Multiplicative Adjustments

Year	Case	Scenario	LDGV	LDGT1	LDGT2
2007	BASELINE	IM CG	1.000	1.000	1.000
		IM RFG	1.000	1.000	1.000
		NO IM CG	1.000	1.000	1.000
		NO IM RFG	1.000	1.000	1.000
	CONTROL	IM CG	0.970	0.963	1.000
		IM RFG	0.975	0.961	1.000
		NO IM CG	0.985	0.985	1.000
		NO IM RFG	0.983	0.986	1.000
2030	BASELINE	IM CG	1.000	1.000	1.000
		IM RFG	1.000	1.000	1.000
		NO IM CG	1.000	1.000	1.000
		NO IM RFG	1.000	1.000	1.000
	CONTROL	IM CG	0.796	0.778	0.857
		IM RFG	0.818	0.766	0.828
		NO IM CG	0.902	0.923	0.958
		NO IM RFG	0.911	0.927	0.961

APPENDIX D

Adjustment Factors for PM and SOx

Table D-1
PM Multiplicative Adjustments

Year	Case	Scenario	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT
2007	BASELINE	IM CG	1.000	1.000	1.000	1.000	1.000	1.000
		IM RFG	1.000	1.000	1.000	1.000	1.000	1.000
		NO IM CG	1.000	1.000	1.000	1.000	1.000	1.000
		NO IM RFG	1.000	1.000	1.000	1.000	1.000	1.000
	CONTROL	IM CG	0.415	0.342	0.370	0.767	0.826	0.800
		IM RFG	0.624	0.563	0.591	0.848	0.826	0.800
		NO IM CG	0.415	0.342	0.370	0.767	0.826	0.800
		NO IM RFG	0.624	0.563	0.591	0.848	0.826	0.800
2030	BASELINE	IM CG	1.000	1.000	1.000	1.000	1.000	1.000
		IM RFG	1.000	1.000	1.000	1.000	1.000	1.000
		NO IM CG	1.000	1.000	1.000	1.000	1.000	1.000
		NO IM RFG	1.000	1.000	1.000	1.000	1.000	1.000
	CONTROL	IM CG	0.417	0.333	0.333	0.767	0.109	0.107
		IM RFG	0.625	0.556	0.556	0.848	0.109	0.107
		NO IM CG	0.417	0.333	0.333	0.767	0.109	0.107
		NO IM RFG	0.625	0.556	0.556	0.848	0.109	0.107

Table D-2
SOx Multiplicative Adjustments

Year	Case	Scenario	LDGV	LDGT1	LDGT2	HDGV	MC
2007	BASELINE	IM CG	1.000	1.000	1.000	1.000	1.000
		IM RFG	1.000	1.000	1.000	1.000	1.000
		NO IM CG	1.000	1.000	1.000	1.000	1.000
		NO IM RFG	1.000	1.000	1.000	1.000	1.000
	CONTROL	IM CG	0.088	0.088	0.088	0.088	0.088
		IM RFG	0.224	0.224	0.224	0.224	0.224
		NO IM CG	0.088	0.088	0.088	0.088	0.088
		NO IM RFG	0.224	0.224	0.224	0.224	0.224
2030	BASELINE	IM CG	1.000	1.000	1.000	1.000	1.000
		IM RFG	1.000	1.000	1.000	1.000	1.000
		NO IM CG	1.000	1.000	1.000	1.000	1.000
		NO IM RFG	1.000	1.000	1.000	1.000	1.000
	CONTROL	IM CG	0.088	0.088	0.088	0.088	0.088
		IM RFG	0.224	0.224	0.224	0.224	0.224
		NO IM CG	0.088	0.088	0.088	0.088	0.088
		NO IM RFG	0.224	0.224	0.224	0.224	0.224